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Assessing Innovative National Policy Options and Roles for CCS in a Post-Kyoto Framework

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Abstract

The highly contentious, complex negotiations over the past several years to establish a globally more-inclusive, post-Kyoto Framework illustrate the daunting complexity and diversity of interests, which had to be accommodated. Notwithstanding the many challenges, a "Copenhagen Accord" was reached at the December 2009 15th Conference of Parties (COP 15) of the United Nations Framework Convention on Climate Change (UNFCCC) held in Copenhagen, Denmark. That Accord provided the basis for subsequent delineation of the post-Kyoto Framework in 2010 at the meetings in Mexico City, Mexico.

Adoption of more flexibility in the approaches nations can employ to achieve significant, verifiable emissions reductions is among the many critical and necessary accommodations made to achieve more inclusive participation from developing economies and other large economies that did not adhere to the Kyoto Protocol. Negotiations also had to address trade and national sovereignty issues as well. This flexibility is an essential recognition of national and cultural differences including differences in levels of national and sub-national economic wealth and growth, status of energy infrastructure development, and national energy resource endowments.

This paper presents research findings from a project using a step-by-step methodology. The first step was defining a set of generic, guiding principles for economically efficient and effective national emissions reduction programs. These were employed to design a comprehensive portfolio of innovative national policy and technology strategies that could be adopted by large, developed economies as well as some large developing economies. A specific example is presented using the United States as the test case. The cost-effectiveness of the innovative policy and technology portfolio is assessed for the test case based on a number of effectiveness measures, including: projected economic impacts and emissions reductions, national security impacts, energy-related impacts on water use and other environmental aspects, and regional economic equity.

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The assessment methodology employs a Reference Case Scenario (RCS), based on the Annual Energy Outlook 2010 energy projections (AEO 2010) of the U.S. Energy Information Agency (EIA), extended through 2050. The EIA energy projections are a widely used basis for projecting future energy demand, supply, and prices in the United States. They provide a comprehensive economy-wide reference data set. Particular attention is given to the electric generation, transportation, and industrial sectors, which account for the majority of energy production, demand, and emissions.

A Policy and Technology Innovations Scenario (PTIS) is constructed covering all sectors of the energy economy with special attention as described above. The case specifications include new Federal and State legislative innovations and modifications to existing laws, regulatory reforms and innovations, and enhanced low-carbon technology innovation programs. Based on the PTIS case specifications, the incremental energy, economic, emissions, and other impacts from successful adoption and implementation of the PTIS case are projected as changes to the Reference Case Scenario using transparent techno-economic modeling approaches.

The enhanced, low-carbon energy technology innovations programs included in the PTIS case cover a broad spectrum of energy supply and demand innovations. Particular attention is given to innovations that increase energy efficiency in both production and uses of energy in all economic sectors. Recognizing the extremely large energy infrastructure and imbedded capital investments already existing in the United States, special attention is given to innovations to transform and expand that infrastructure to meet future clean energy needs. The latter is a key strategy for making the transition affordable. One focus of attention is innovative opportunities for Carbon Capture and Sequestration (CCS). These are described along with the policy, regulatory, and technology improvements necessary to enable those contributions.

The quantitative and qualitative differences between the two Scenarios are compared using the effectiveness measures adopted. These comparisons confirm that a portfolio such as that modeled in this project can lead to significant, affordable emissions reductions in the near term, and establish a pathway to a future energy economy with much larger reductions in energy use and emissions than the Reference Case in the longer term. Other key insights and conclusions from the assessment are described. The national and sub-national political, economic, and regulatory barrier and constraint challenges to successful implementation of a PTIS case are presented along with options for overcoming those challenges.

Keywords: Assessment; Policy Options; CCS

Introduction

Almost a full year after emergence of the "Copenhagen Accord," a stalemate continues to exist in developing a consensus on more flexible approaches that can be adopted by individual nations under a New Framework based on the Accord.

Policies of the major developed economies continue to focus on refining and repackaging adaptations of Cap and Trade (or Cap and Tax as some sources have named it) approaches based on the conventional pollution control paradigm, despite the vastly more complex problems of developing and implementing clean energy solutions. Opponents claim those efforts make all energy more expensive and lead to creating financial derivatives (allowances) which can become the vehicles for the next international finance "bubble economy." Concern has also arisen over the credibility and value of "international offsets" which are a key to cost containment in these approaches.

The major developed economies continue to experience serious economic and fiscal deficit problems due to slow recovery of economic growth, and job creation. Little attention is being given to addressing the interaction of energy policies with other quality of life issues such as water and land use, affordable food supplies, and continued energy security concerns [1]. Significant reductions in greenhouse gas emissions have occurred in these economies in recent years, but that has been primarily due to the deep and extended recessions experienced, particularly in the United States.

The relative success of the contrasting energy and economic policies being pursued by the large developing economies is readily apparent from the large differences in economic growth rates and job creation being experienced there. The major developing economies are aggressively pursuing policies that favor development of affordable energy, economic growth, and improved quality of life for their citizens, including large public investments in developing affordable clean energy production and use from both conventional and alternative energy sources and technologies.

China is clearly the leading example of this strategy with growth in both conventional energy supply and technology industries, and in wind energy, solar energy, battery, electric vehicle, and components industries. These industries in China have become dominant suppliers to both domestic and export markets. Examples of this dominance were reported in a recent *Business Week* article [2]. Policy makers, alternative energy advocacy groups and mainstream media tout the huge potential manufacturing and other job growth potential within developed economies in these same current “green” alternative energy industries. Given the level of investment, scale of operations, and jobs in these technology areas within China, an objective observer would have to question the plausibility of becoming competitive with China. Past experiences from the transition of the consumer electronics and computer industries to Asia indicate that is quite unlikely.

China’s most prominent public investments and industrial growth in the clean energy industries are cited above. The very large investments in research, development, and deployments of advanced, clean conventional energy technologies are less well known and not publicized. These investments are being made for both domestic uses and for export markets and include high efficiency clean coal technologies (both without and with carbon capture) for electric generation, industrial feedstocks, and fuels including synthetic natural gas. Other large conventional energy developments include domestic conventional and unconventional natural gas [3,4], and large investments to acquire ownership positions in conventional and unconventional oil resources and production globally, acting through government-owned entities.

In summary, the major developing economies, particularly that of China, adopted and will continue to pursue very different energy and climate policies than those the major developed economies are pursuing. Their strategies for transitioning to a cleaner global energy economy include both domestic and global market participation and the attendant economic and jobs growth benefits. These strategies appear to be contributing to larger economic growth rates, increased energy security, and improved quality of life for their citizens than the policies currently being pursued and produced by the major developed economies.

Re-Framing Energy and Climate Policy Issues and Challenges

Over the past several years a number of very thoughtful experts have examined how the framing of these issues and challenges has evolved, and how that has locked-in policy prescriptions based upon oversimplified analogies to solving conventional environmental pollution problems. One fundamental assumption of “Cap and Trade” and “Carbon Tax” advocates is that adequate technology to achieve deep emissions reductions at reasonable economic costs already exist, or will be easily forthcoming due to rising energy prices. A number of experts dispute that assumption and have identified a need for massive public investments in scientific and engineering research, development, and demonstrations to identify radically innovative new technologies rather than locking-in the limited current portfolio of technologies. These experts advocate adopting innovative new policies designed to make clean energy more affordable rather than continuing to pursue policies that make all energy more expensive.

One very notable recent report by a group of respected experts is the May 2010 publication entitled "A new direction for climate policy after the crash of 2009," from The London School of Economics [1]. That report calls for a "Radical Re-Framing" of international and national climate policies. The proposed re-framing includes three basic themes. The first is returning to a focus on reducing non-carbon dioxide "forcers" as part of the new directions. These include both energy-related and unrelated "forcers" which are not receiving the front line attention they deserve. Second is ensuring that the best is not the enemy of the good in a complex world. This theme builds on a concept referred to as the "Kaya Direct" approach which derives from the work of Professor Yoichi Kaya of Japan. The third is an innovative approach to pay for what needs to be funded through fee-based approaches rather than a carbon tax regime or cap and trade scheme. Readers interested in the full proposal for new directions can study the reference.

This paper focuses on the second and third themes. It employs a "Kaya Direct" approach, and addresses the question of how to pay for necessary actions drawing from earlier SFA Pacific research and reports [4,5,6]. The approach starts with examination of the Kaya Identity which expresses the relationship among the four macroscale policies that determine the level of carbon emissions produced by an economy. They are population (P), per-capita wealth (GDP/P), energy intensity of the economy (E/GDP), and carbon intensity of the energy (C/E). These four policies are the levers that can be used to change carbon emission levels of an economy. This paper does not deal with the first two levers. The relationship can be expressed as:

$$C = P^* \, (GDP/P)^* \, (E/GDP)^* \, (C/E) \tag{1}$$

Energy intensity is a measure of both how efficiently energy is used, and the mix of economic activities from very energy intensive to non-energy intensive. The first priority in the "Kaya Direct" approach is to pursue increased energy efficiency. However, there are limits as the law of diminishing returns sets in. The least energy efficient economic sectors should be the highest priority targets. Reducing energy intensive economic activity also reduces energy intensity. However, if the products of those energy-intensive activities are necessary to the economy, they then have to be imported and paid for in some way. Carbon intensity reduction or decarbonization is by far the most challenging to implement and requires radical innovation in policies and technologies. It is the most important theme for greenhouse gas reductions over the longer term. Carbon capture and storage is one of the key approaches to achieving significant progress in decarbonization.

Applying a "Kaya Direct" Approach in the United States

The proposed Policy and Technology Innovation Scenario (PTIS) builds on previously published scenario research [5,6]. It incorporates refinements and updated data from other recently published SFA Pacific reports including a report on the prospects for the U.S. natural gas industry based on recent developments in unconventional gas [4]. It also draws from an ongoing SFA Pacific multiclient study entitled "CO_2 Mitigation—Phase II, A Technical Business Analysis" [7]. Energy projections from the recent EIA AEO 2010 are the basis for quantitative assessments [8].

Part one of the PTIS agenda emphasizes implementation of aggressive policy actions to sustain progress in improved energy efficiency in all economic sectors, with the goal of achieving projected outcomes from a new AEO 2010 Integrated High Technology (IHT) Case. This new integrated AEO case is used in place of independent estimates previously used. The PTIS policy agenda includes actions to assure that existing energy efficiency and renewable energy tax credits and policies will be extended beyond the expiration dates assumed in the Reference Case. Other features include strengthening already enacted provisions requiring regular, periodic revisions to energy efficiency standards, and extending sunset provisions of selective enacted legislation.

Part two focuses on the Light Duty Vehicle (LDV) segment of the Transportation Sector, the primary transportation source of liquid fuel demand and carbon emissions. In the IHT case it remains one of the least energy efficient economic sectors. The PTIS policy agenda includes more aggressive, regular updating of fuel standards plus other policies to increase fleet average efficiency to 40 mpg by 2035, and to 50 mpg by 2050. Current technology options are described in Reference 5 and other sources. One innovative policy option is legislation that establishes a schedule for updates along with default increases that would become effective, absent actions to meet the schedule. Pre-determined schedules and default updates would help industry set longer term research and business plans.

Part three focuses on increasing energy efficiency of electricity generation, another of the least energy efficient economic sectors. During the energy crises of the late 1970s policy and regulatory reforms were initiated to open opportunities for increased competition in natural gas supply and electricity supply markets with the goal of increasing affordable energy supplies. Thirty years later, the natural gas supply market has been transformed into a highly efficient, competitive energy sector as described in reference [4]. Many years and generations of policy revisions and regulatory reforms plus significant technology innovations were necessary along the way. Progress in opening electricity markets for increased competition and energy efficiency in the generation sector has been far less successful and has not progressed significantly since the late 1990s.

This focus starts with returning to the task of implementing new, innovative policies and regulatory reforms in the generation segment of the electricity industry to increase competition among potential suppliers of affordable high efficiency, lower emission generation from fossil energy fuels. Proposed actions include reforms to both Federal and State regulatory regimes for the generation sector that can open generation markets for a range of currently available, underutilized fossil generation approaches and advanced technologies. The proposed policy innovations include implementation of generation efficiency standards, revised economic dispatch algorithms that give dispatch priority to high energy efficiency and low carbon emissions, and requirements for periodic, competitive capacity planning processes. For more on these options see References 5 and 6.

Accomplishing this transition will come at a cost to consumers and electricity producers. The proposed cost containment strategy is to fund it through a small "Carbon Management Investment Fee" imposed on all fossil fuel-fired generation. Some sources prefer to call it a tax. Whatever it is called, it should be available only for the designated purposes of reinvestment in performance-based production incentives for qualifying increased efficiency, lower carbon emissions fossil fuel-fired generation, with a designated portion of the fund for fundamental research on radically new low carbon emission technologies to produce and use fossil fuels. The user fee must be deposited in a revolving fund in the U.S. Treasury, available only for the designated purposes, as opposed to being deposited in the general revenue accounts. Variations of an approach and technical details have been proposed by several sources including Reference 5.

Based on the AEO 2010 Reference Case Table A8, annual fossil fuel-fired generation projections are about 2,500 billion kilowatt hours (kWh) [8]. A generation fee of about 0.5¢/kWh could produce an annual revolving fund deposit of $12.5 billion and a five year total of $62.5 billion. With interest it would exceed $70 billion or more within five years. Implementation of qualifying generation production would likely require about five years to become operational, at which time payout of the performance-based incentives would begin, and continue for a predetermined operating period.

A new production tax credit for high efficiency, low-carbon emission generation from fossil energy sources is proposed. This draws on experience with the very successful Section 29 Unconventional Gas Production Credit [4]. A key feature of the new production tax credit is the two tiers of qualifying generation with different levels of credits. The highest tier would be available for generation that results in energy efficiency of 50% or greater and captures and sequesters 90% of the carbon emitted from generation. A second, lower tier would be available for generation that exceeds 50% efficiency and meets a carbon emission standard. That standard would allow a lesser reduction in carbon emissions, and increase the portfolio of higher efficiency, low-carbon generation approaches that qualify. Further discussion of these concepts is included in References 5 and 6.

Currently available options for qualifying generation include coal-fired generation from industrial gasification projects that can readily incorporate CCS at efficiencies of 50% or more compared with existing coal-fired generation efficiencies in the mid-30% range; generation from coal-by-gas pipeline using synthetic natural gas (SNG) produced with CCS; and natural gas combined cycle plants. Increased potential for the latter option has emerged as a result of recent trends in the domestic natural gas supply market [4]. The projected low growth rate of new coal-fired generation in AEO 2010, indicates most implementation would come from replacement of older existing coal-fired generation. For additional discussion of the technology options see Reference 5.

The PTIS is based on replacing 60 Gigawatts (GW) of conventional coal-fired generation out of the 325 GW projected for 2035 in the RCS with a portfolio of higher efficiency, lower carbon emission fossil fuel-fired generation. The assumed mix of replacement capacity includes 30 GW based on industrial gasification approaches which include CCS. The assumed balance is 15 GW of natural gas-fired generation and 15 GW of gas combined cycle generation using coal-based SNG with CCS.

Early CCS implementation is through sale of the byproduct carbon dioxide from gasification-based projects for enhanced recovery of domestic oil resources with subsequent sequestration in those reservoirs. Recently published research results confirm that more than enough storage capacity is available in oil reservoirs. The results significantly increase both oil production potential, and the carbon dioxide storage capacity [9,10]. The resulting increased domestic production would displace oil imports as well as increase efficiency of oil resource recovery.

Assessing Effectiveness of the Proposed PTIS Action Plan

The Reference Case Scenario (RCS). The EIA AEO 2010 Reference Case is the RCS [8]. Based on late 2009 economic projections the Reference Case assumes GDP will return to pre-recession levels by 2011. More recent economic projections from various sources indicate this is highly unlikely until after 2012. Even with that assumption, unemployment levels are not projected to return to pre-recession levels until 2019. While GDP is projected to grow at an annual rate of 2.4%, industrial sector growth is projected at only 1.5%. The energy intensive manufacturing sector growth is projected at only 0.8%, and some subsectors continue to decline. These macroeconomic trends explain the projected low jobs and energy growth and continued significant decline in energy intensity of GDP. The political sustainability of current economic and energy policies that lead to these projected rates of economic and jobs growth economic outcomes remains to be determined.

Projected annual carbon dioxide emissions reach the 2007 peak level of about 6,000 million metric tonnes (mt) about 2025, and reach 6,320 million mt by 2035, with 75% of that from the Transportation and Electricity Generation sectors. Oil imports are projected to decline to 8.65 million bbl/d by 2035, still almost 60% of projected oil demand.

Measuring the Effectiveness of the Proposed PTIS. The PTIS is a highly cost-effective approach for achieving important economic, energy security, and environmental goals over the next 30-50 years while building the industrial infrastructure for transition to a longer term clean energy economy. It does so at an affordable cost to consumers while not increasing deficit public spending. Compared to the Reference Case, two readily quantifiable impacts are estimated. By 2035, oil imports are reduced by 2.5 million bbl/d through efficiency innovations in the LDV segment of the Transportation sector. Carbon dioxide emissions are reduced over 275 million mt/yr. By 2050, an additional 1.5 million bbl/d of import reductions and an additional 170 million mt of carbon emissions reduction would occur.

By 2035, other energy efficiency improvements, including in electric generation, would reduce carbon emissions by another 400 million mt. Decarbonization of electricity generation through CCS adds another 165 million mt, and reduces oil imports by an additional 1.0 million bbl/d. The total carbon emissions reduction of 840 million below the Reference Case level leads to a level equal to 1996 emissions, well below the 2007 peak level. Total import reductions are 3.5 million bbl/d. Early introduction of CCS contributes significantly to both of these important benefits. By 2050, assuming an additional 60 GW are converted, further reductions of another 275 million mt of carbon emissions and 1.0 million bbl/d in oil imports would occur.

These outcomes would lead to increased domestic jobs and economic growth beyond the Reference Case levels. The extent of those benefits remains to be quantified. Additional unquantified benefits include reduced electricity generation demands for water due to the introduction of more combined cycle technologies; decreased costs to consumers from implementation of the revised Clean Air Interstate Rule (CAIR) requirements for electricity generation [8]; new infrastructure development for the longer term clean energy economy; and, accelerated scientific research, development, demonstration, and deployment of radically innovative clean fossil energy technologies for the long term.

Summary

The proposed PTIS provides a new innovative flexible approach to cost-effectively achieving significant energy intensity reductions and increased decarbonization following a "Kaya Direct" approach and the Copenhagen Accord. This is accomplished while significantly increasing energy security by reducing oil imports and it increases the recovery efficiency of oil resources, an important natural resource. All of these benefits can be achieved at the same time as other important environmental and quality of life benefits, including increased domestic growth rates of the economy and well paying jobs.

Early, large scale adoption of CCS is an essential component of the PTIS. This can be initiated through productive uses of captured carbon dioxide as an important factor of production in a more efficient recovery of stranded oil resources. Early adoption can provide the investment capital to start building the new infrastructure necessary for longer term expansion of CCS as one of the pathways toward decarbonization of the U.S. energy economy.

Importantly, these results are achieved without requiring large increases in energy costs to consumers, or increases in public deficit spending, through the proposed cost containment approach. That approach provides a funding source for required production incentives that stimulate a transition to more affordable, low-carbon electricity from fossil fuels and for significantly increasing funding research and deployment of longer term radically innovative fossil energy-based technologies.

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